Appl. No. : 09/316,518
Filed : May 21, 1999

AMENDMENTS TO THE CLAIMS

1-23 (Cancelled)

24. (Currently Amended) A method for adaptively duplexing transmissions in a communication link using a time division duplexing scheme wherein transmissions are communicated in an uplink direction during uplink time slots and wherein transmissions are communicated in a downlink direction during downlink time slots, comprising the steps of:

(a) ~~determining~~ predicting an uplink bandwidth requirement and a downlink bandwidth requirement of the communication link, wherein the uplink and downlink bandwidth requirements are determined using associated and respective uplink and downlink bandwidth utilization parameters;

(b) calculating an uplink/downlink bandwidth requirement ratio based upon the uplink and downlink bandwidth requirements of the link;

(c) allocating uplink and downlink time slots in a frame in response to the calculated uplink/downlink bandwidth ratio; and

periodically enabling uplink transmissions during the allocated uplink time slots and downlink transmissions during the allocated downlink time slots.

25. (Previously Presented) The method of Claim 24, wherein the uplink and downlink bandwidth requirements are initially determined when the link is installed in the communication system.

26. (Previously Presented) The method of Claim 24, wherein the uplink and downlink bandwidth requirements are determined by periodically monitoring the bandwidth utilization parameters for uplink and downlink transmissions in the communication link.

27. (Previously Presented) The method of Claim 24, wherein the uplink and downlink bandwidth requirements are determined by periodically monitoring requests for uplink and downlink transmissions in the communication link.

28. (Previously Presented) The method of Claim 24, wherein the bandwidth requirements are periodically determined and the associated uplink/downlink bandwidth requirement ratio for the link is periodically updated, and wherein the uplink and downlink time slot allocations are updated periodically in response to the updated uplink/downlink bandwidth ratio.

29. (Previously Presented) The method of Claim 28, wherein the uplink and downlink bandwidth requirements are periodically determined by continuously monitoring the transmissions in the communication link.

30. (Previously Presented) The method of Claim 24, wherein the uplink and downlink bandwidth requirements vary depending upon the type of service provided over the communication link.

31. (Previously Presented) The method of Claim 24, wherein the uplink and downlink bandwidth requirements vary depending upon the type of user of the communication link.

32. (Previously Presented) The method of Claim 24, wherein the communication link comprises a wireless communication link.

33. (Previously Presented) The method of Claim 24, wherein the uplink and downlink time slots are dynamically allocated using a frame-based time slot allocation approach.

34. (Previously Presented) The method of Claim 33, wherein a frame comprises N time slots, and wherein the frame-based time slot allocation approach comprises allocating a first number N_1 time slots (where N is greater than or equal to N_1) for downlink transmissions only, and allocating the remaining N_2 time slots for uplink transmissions only (where N_2 equals N-N_1).

35. (Previously Presented) The method of Claim 33, wherein a frame comprises N time slots, and wherein the frame-based time slot allocation approach comprises allocating a first number N_1 time slots (where N is greater than or equal to N_1) for downlink transmissions only, and allocating the remaining N_2 time slots for both uplink and downlink transmissions (where N_2 equals N-N_1).

36. (Previously Presented) The method of Claim 33, wherein a frame comprises N time slots, and wherein the frame-based time slot allocation approach comprises allocating a first number N_1 time slots (where N is greater than or equal to N_1) for uplink transmissions only, and allocating the remaining N_2 time slots for downlink transmissions only (where N_2 equals N-N_1).

37. (Previously Presented) The method of Claim 33, wherein a frame comprises N time slots, and wherein the frame-based time slot allocation approach comprises allocating a first number N_1 time slots (where N is greater than or equal to N_1) for uplink transmissions only, and allocating the remaining N_2 time slots for both uplink or downlink transmissions (where N_2 equals N-N_1).

38. (Previously Presented) The method of Claim 24, wherein the uplink and downlink bandwidth requirements are determined using a plurality of associated uplink and downlink statistical bandwidth parameters.

39. (Previously Presented) The method of Claim 38, wherein the statistical bandwidth parameters comprise both an initial and actual set of statistical parameters reflective of the bandwidth requirements of the communication link.

40. (Previously Presented) The method of Claim 39, wherein the initial set of statistical parameters are set when the communication link is installed, and wherein the actual set of statistical parameters are periodically updated as the uplink and downlink bandwidth utilization of the communication link varies.

41. (Previously Presented) The method of Claim 40, wherein the initial set of statistical parameters are based upon an estimate of the number of users and the type of user of the communication link.

42. (Currently Amended) An apparatus for adaptively duplexing transmissions in a communication link of a wireless communication system using a time division duplexing scheme wherein transmissions are communicated in an uplink direction during uplink time slots and wherein transmissions are communicated in a downlink direction during downlink time slots, comprising:

(a) means for ~~determining~~ predicting an uplink bandwidth requirement and a downlink bandwidth requirement of the communication link, wherein the uplink and downlink bandwidth requirements are determined using associated and respective uplink and downlink bandwidth utilization parameters;

(b) means, responsive to the determining means, for calculating an uplink/downlink bandwidth requirement ratio based upon the uplink and downlink bandwidth requirements of the link;

(c) means, responsive to the calculating means, for allocating uplink and downlink time slots in a frame in accordance with the uplink/downlink bandwidth requirement ratio; and

means for periodically enabling uplink transmissions during the allocated uplink time slots and downlink transmissions during the allocated downlink time slots.

43. (Previously Presented) The apparatus of Claim 42, wherein the uplink and downlink bandwidth requirements are determined by periodically monitoring the bandwidth utilization parameters for uplink and downlink transmissions in the communication link.

44. (Previously Presented) The apparatus of Claim 42, wherein the uplink and downlink bandwidth requirements are determined by periodically monitoring requests for uplink and downlink transmissions in the communication link.

45. (Previously Presented) The apparatus of Claim 42, wherein the determining, calculating and allocating means comprise a computer program executing on a programmable processor.

46. (Previously Presented) The apparatus of Claim 45, wherein the programmable processor is in a cluster controller, and wherein the cluster controller controls a plurality of base stations in the wireless communication system, and wherein one selected base station controls transmissions in the communication link.

47. (Previously Presented) The apparatus of Claim 46, wherein the communication link comprises a wireless communication between the selected base station and a CPE.

48. (Currently Amended) A method for duplexing transmissions in a communication link using a time division duplexing scheme wherein transmissions are communicated in an uplink direction during uplink time slots and wherein transmissions are communicated in a downlink direction during downlink time slots, comprising the steps of:

(a) ~~determining~~ predicting uplink and downlink bandwidth requirements in accordance with associated and respective quality of service session bandwidth parameters to establishing an uplink/downlink bandwidth requirement ratio;

(b) allocating uplink and downlink time slots in a frame in response to the uplink/downlink bandwidth ratio; and

(c) periodically enabling uplink transmissions during the allocated uplink time slots and downlink transmissions during the allocated downlink time slots.

49. (Previously Presented) The method of Claim 46, wherein the uplink and downlink bandwidth requirements are determined when the link is installed in the communication system.

50. (Previously Presented) The method of Claim 46, wherein the uplink and downlink bandwidth requirements vary depending upon the type of service provided over the communication link.

51. (Previously Presented) The method of Claim 46, wherein the uplink and downlink bandwidth requirements vary depending upon the type of user of the communication link.

52-69. (Cancelled)

70. (Previously Amended) A method for monitoring and updating uplink and downlink bandwidth requirements in a wireless communication system including a base station and at least one CPE, the method comprising:

initializing the base station with an initial set of bandwidth utilization parameters, including a first estimate of the uplink and downlink bandwidth requirements of at least one CPE in a frame;

monitoring bandwidth use by the at least one CPE and the base station; and

updating the initial set of bandwidth utilization parameters with an actual set of bandwidth utilization parameters based on the monitoring.

71. (Previously Presented) The method of Claim 70, wherein updating the initial set of bandwidth utilization parameters includes determining a second estimate of the uplink and downlink bandwidth requirements of the at least one CPE.

72. (Cancelled)

73. (Currently Amended) A method for adaptively duplexing transmissions in a communication link using a time division duplexing scheme wherein transmissions are communicated in an uplink direction during uplink time slots and wherein transmissions are communicated in a downlink direction during downlink time slots, the method comprising:

~~determining~~ predicting an initial uplink bandwidth requirement and an initial downlink bandwidth requirement of the communication link;

calculating an initial uplink/downlink bandwidth requirement ratio based upon the initial uplink and initial downlink bandwidth requirements of the link;

allocating initial uplink and downlink time slots in a frame in response to the calculated initial uplink/downlink bandwidth ratio;

transmitting information during the initial uplink and downlink time slots;

determining an actual uplink bandwidth requirement and an actual downlink bandwidth requirement based on the transmission during the initial uplink and downlink time slots;

calculating an actual uplink/downlink bandwidth requirement ratio based upon the actual uplink and actual downlink bandwidth requirements of the link;

allocating actual uplink and downlink time slots in response to the calculated actual uplink/downlink bandwidth ratio; and

transmitting information during the actual uplink and downlink time slots.

74-77 (Cancelled)

78. (Previously Presented) A method for monitoring and updating uplink and downlink bandwidth requirements for a communication link using a time division duplexing scheme wherein transmissions are communicated in an up link direction during uplink time slots and wherein transmissions are communicated in a downlink direction during downlink time slots, comprising:

(a) determining an initial set of bandwidth utilization parameters, wherein the initial bandwidth utilization parameters comprise an estimate of the uplink and downlink bandwidth requirements; and

(b) updating the initial set of bandwidth utilization parameters with an actual set of bandwidth utilization parameters reflective of an actual bandwidth utilization of the uplink and downlink time slots, wherein the actual set of bandwidth parameters are calculated as follows:

$$\begin{pmatrix} U^{(M)}{}_{n+1} \\ D^{(M)}{}_{n+1} \end{pmatrix} = \alpha_M \begin{pmatrix} U^{(M)}{}_{n} \\ D^{(M)}{}_{n} \end{pmatrix} + (1-\alpha_M) \begin{pmatrix} (U_n - U^{(1)}{}_n)^M \\ (D_n - D^{(1)}{}_n)^M \end{pmatrix} \quad \text{wherein } \alpha_M < 1,\ M > 1$$

$$\begin{pmatrix} U^{(1)}{}_{n+1} \\ D^{(1)}{}_{n+1} \end{pmatrix} = \alpha_1 \begin{pmatrix} U^{(1)}{}_{n} \\ D^{(1)}{}_{n} \end{pmatrix} + (1-\alpha_1) \begin{pmatrix} U_n \\ D_n \end{pmatrix} \quad \text{and wherein } \alpha_1 < 1,\ M = 1;$$

and wherein $U^{(M)}{}_n$, $D^{(M)}{}_n$ comprise uplink and downlink filtered moments, respectively, of order M at an instant n, and wherein U_n, D_n respectively comprise an uplink and downlink accumulated bandwidth requirement influenced by the actual bandwidth utilization.

79. (Previously Presented) The method of Claim 78, wherein the initial set of bandwidth utilization parameters is periodically updated with the actual set of bandwidth parameters calculated in step (b).

80. (Previously Presented) The method of Claim 78, further comprising monitoring rejected transmissions, wherein the following parameters are updated when transmissions are rejected:

$$\begin{pmatrix} U'_{n+1} \\ D'_{n+1} \end{pmatrix} = \gamma_1 \begin{pmatrix} U'_n \\ D'_n \end{pmatrix} + (1-\gamma_1)\begin{pmatrix} \delta U \\ \delta D \end{pmatrix} \quad \text{wherein } \gamma_1 < 1;$$

and wherein U'_n, D'_n comprise a moving average of the uplink and downlink bandwidth requirements of rejected sessions.

81. (Previously Presented) The method of Claim 78, further comprising monitoring rejected transmissions, wherein the following parameters are updated when transmissions are not rejected:

$$\begin{pmatrix} U'_{n+1} \\ D'_{n+1} \end{pmatrix} = \gamma_2 \begin{pmatrix} U'_n \\ D'_n \end{pmatrix} \quad \gamma_2 < 1;$$

and wherein U'_n, D'_n comprise a moving average of the uplink and downlink bandwidth requirements of rejected sessions.

82. (Previously Presented) A method for monitoring and updating uplink and downlink bandwidth requirements for transmissions across a communication link in a wireless communication system, wherein the transmissions occur during frames comprising N time slots wherein $N_1, N_2, \ldots N_M$ are positive integers, and wherein $\sum_{k=1}^{M} N_k = N$, comprising:

(a) summing all of the uplink bandwidth requirements as follows: for each integer value of k between 1 and M, $S_u^{(k)} = \sum^k \sqrt{U'^{(k)}}$;

(b) summing all of the downlink bandwidth requirements as follows: for each integer value of k between 1 and M, $S_d^{(k)} = \sum^k \sqrt{D'^{(k)}}$;

(c) calculating an estimated bandwidth allocation scheme as follows:

$$\hat{N}_d = INT\left[\sum_{k=1}^{M} \frac{N_k S_d^{(k)}}{S_d^{(k)} + S_u^{(k)}}\right], \quad \hat{N}_u = N - \hat{N}_d;$$

(d) comparing the estimated bandwidth allocation scheme calculated in step (c) with the allocation scheme currently used, wherein the allocation scheme currently used is defined as N_d, N_u; and

(e) replacing N_d and N_u with the estimated bandwidth allocation scheme calculated in step (c) if $\left|N_d - \hat{N}_d\right| \geq \mu$, wherein μ comprises a pre-determined threshold.

83. (Previously Presented) The method of Claim 82, further comprising monitoring rejected transmissions.

84. (Previously Presented) The method of Claim 83, wherein monitoring transmissions comprises:

summing all of the rejected uplink bandwidth requirements as follows: $S'_u = \sum U'$;

summing all of the rejected downlink bandwidth requirements as follows: $S_d' = \sum D'$; and

calculating an expected allocation scheme as follows: $\begin{pmatrix} \tilde{N}_u \\ \tilde{N}_d \end{pmatrix} = \frac{1}{S'_d + S'_u} \begin{pmatrix} S'_u \\ S'_d \end{pmatrix}$.

85. (Previously Presented) The method of Claim 84, further comprising updating the bandwidth allocation scheme when the number of rejected transmissions exceeds a predetermined threshold.

86. (Previously Presented) The method of Claim 85, wherein the bandwidth allocation scheme is updated in accordance with the following:

(a) determining *if* $Max(S_u', S_d') > S_o$, wherein S_o is a constant, if so then proceeding to step (b);

(b) determining *if* $\left|N_d - \tilde{N}_d\right| > \mu$, wherein μ is a constant, if so then proceeding to step (c);

(c) determining *if* $\tilde{N}_d > N_d$ and $N_d < N - \delta$, wherein δ is a constant, if so then updating the downlink allocation N_d as follows: $N_d \leftarrow N_d + \delta$;

(d) determining *if* $\tilde{N}_d < N_d$ and $N_d > \delta$, if so then updating the downlink allocation N_d as follows: $N_d \leftarrow N_d - \delta$;

(e) updating the uplink allocation N_u whenever the downlink allocation is updated in either steps (c) or (d) as follows: $N_u \leftarrow N - N_u$; and

(f) updating the bandwidth allocation parameters whenever the values of N_d and N_u are updated.

87. (Previously Presented) The method of Claim 86, further comprising alerting the wireless communication system if $Max(S_u', S_d') > T$, wherein T is a predetermined threshold value.

88. (Currently Amended) A method for adaptively duplexing transmissions between a base station and at least one CPE using a series of uplink and downlink frames of information in an adaptive time division duplexing scheme, wherein transmissions are communicated in an uplink direction during uplink time slots and wherein transmissions are communicated in a downlink direction during downlink time slots, comprising:

selecting a first service type for an uplink transmission;

selecting a second service type for a downlink transmission;

~~determining~~ predicting an uplink bandwidth requirement that is associated with the selected first service type;

~~determining~~ predicting a downlink bandwidth requirement that is associated with the selected second service type;

calculating an uplink/downlink bandwidth requirement ratio based upon the uplink and downlink bandwidth requirements;

allocating uplink and downlink time slots in a frame in response to the calculated uplink/downlink bandwidth ratio; and

periodically enabling uplink transmissions during the allocated uplink time slots and downlink transmissions during the allocated downlink time slots.

89. (Previously Presented) The method of Claim 88, wherein the first service type is sensitive to transmission delays and the second service type is insensitive to transmission delays.

90. (Previously Presented) The method of Claim 88, further comprising comparing sensitivities to a transmission delay for the first service type and the second service type.

91. (Previously Presented) The method of Claim 90, further comprising shifting the uplink/downlink bandwidth requirement ratio to reduce the transmission delay of the first service type at the expense of increasing the transmission delay of the second service type.

92. (Currently Amended) A method for adaptively duplexing transmissions in a communication link using a time division duplexing scheme wherein transmissions are communicated in an uplink direction during uplink time slots and wherein transmissions are communicated in a downlink direction during downlink time slots, the method comprising:

selecting a quality of service associated with the communication link;

~~determining~~predicting an initial uplink bandwidth requirement and an initial downlink bandwidth requirement of the communication link based on the selected quality of service;

calculating an initial uplink/downlink bandwidth requirement ratio based upon the initial uplink and initial downlink bandwidth requirements of the link;

allocating initial uplink and downlink time slots in a frame in response to the calculated initial uplink/downlink bandwidth ratio;

transmitting information during the initial uplink and downlink time slots;

determining an actual uplink bandwidth requirement and an actual downlink bandwidth requirement based on actual bandwidth utilization during the initial uplink and downlink time slots;

calculating an actual uplink/downlink bandwidth requirement ratio based upon the actual uplink and actual downlink bandwidth requirements of the link;

allocating actual uplink and downlink time slots in response to the calculated actual uplink/downlink bandwidth ratio; and

transmitting information during the actual uplink and downlink time slots.

93. (Previously Presented) The method of Claim 92, wherein the initial uplink bandwidth requirement and the initial downlink bandwidth requirement split the uplink time slots and the downlink time slots into equal portions.

94. (Previously Presented) The method of Claim 92, wherein the initial uplink bandwidth requirement and the initial downlink bandwidth requirement split the uplink time slots and the downlink time slots into unequal portions.

95. (Previously Presented) The method of Claim 94, further comprising calculating the actual uplink/downlink bandwidth requirement ratio based on the selected quality of service.

96. (Previously Presented) The method of Claim 92, wherein the selected quality of service is based on type of service and data latency requirements.